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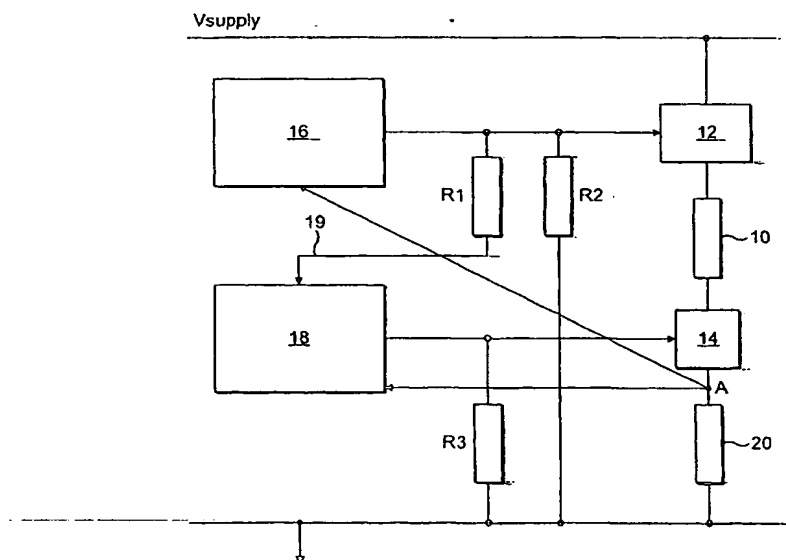
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(54) Title: CONTROL SYSTEM



(57) Abstract: A control system for a load (10), the system comprising a first microprocessor (16) having an output to drive one side of a load (10), a second microprocessor (18) having an output to drive the other side of the load (10), the system being arranged so that when either microprocessor detects a fault in the control of the load (10) the load (10) is switched off.

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Control System

This invention relates to a control system for a load such as a drive mechanism and in particular to a so-called "fail off" control system in which, when a fault is detected, the operation of the load is ceased or switched out.

Control systems generally include fault detection systems which control the operation of the control system when a fault is detected. There are three main types of control system with fault detection: "fail on", in which the mechanism associated with the control system is maintained in an "on" state if a fault is detected (commonly used in situations (e.g. aircraft) in which to turn the system off may result in fatal consequences); "fail off" in which the mechanism associated with the control system is put into an "off" state if a fault is detected (commonly used in situations (e.g. vehicle drive mechanisms) in which to leave the system on may result in fatal consequences); and "do nothing", in which the mechanism associated with the control system is maintained in its current state if a fault is detected and a log of a fault generated for later inspection and solution.

The invention will now be described, by way of example only, with reference to the accompanying drawing, in which:
Figure 1 is a first embodiment of a drive control system.

A method and apparatus for controlling a load is described. In the following description, for the purposes of explanation, numerous specific details are set forth to provide a thorough understanding of the present invention. It will be apparent to a person skilled in the art that the present invention may be practised without these specific details. In other instance, well-known structures and devices are shown in block diagram form to avoid unnecessarily obscuring the present invention.

The needs identified above and other needs and objects that will become apparent from the following description are achieved in the present invention which comprises, in one aspect, a control system for a load, the system comprising a first microprocessor having an output to drive one side of a load
5 and a second microprocessor having an output to drive the other side of the load. The system is arranged so that when either microprocessor detects a fault in the control of the load the load is switched off. In other aspects, the invention encompasses apparatus for carrying out the foregoing steps.

10 The control system to be described is part of the electronic system used in a vehicle such as a car but the method is applicable to other electronic systems, especially those that require fail-off systems.

Figure 1 shows a first embodiment of a drive control system. A load 10 is
15 driven by two drivers, a high side driver 12 and a low side driver 14. The operation of the driver 12 is controlled by a first microprocessor 16 while driver 14 is controlled by a second microprocessor 18. For safety reasons the second microprocessor 18 is provided to monitor the operation of the drive control system. The drivers 12, 14 may take any suitable form e.g. MOSFET
20 switches or the like. The drivers 12, 14 may drive the load 10 by various means such as a Pulse Width Modulation (PWM) signal or the like.

Two microprocessors are provided to ensure a fail-safe operation of the drive control system. In normal operation, the main microprocessor 16 controls the
25 high side driver 12 (the low side driver 14 normally being switched on) and monitors the operation of the load by monitoring the low side of the load 10 at point A. If it detects a fault it can switch off the load via driver 12.

Each microprocessor 16, 18 has programmed into it a set of rules by which the operation of the load is controlled. The set of rules of the second microprocessor 18 may be identical to the set of rules of the first microprocessor. Alternatively, the set of rules of the second microprocessor 18
5 may be coarser than or a subset of the set of rules of the first microprocessor.

In use, the second microprocessor 18 monitors the operation of the first microprocessor 16 and the operation of the load 10 to determine if the system is operating according to the set of rules of the second microprocessor. If either
10 is not operating according to the set of rules of the second microprocessor, the microprocessor 18 switches out the load 10 by means of setting the low side driver 14 to open. Thus the load no longer has any effect on other systems.

In a preferred implementation of the invention, the second microprocessor
15 monitors the outputs of the first microprocessor that controls driver 12 to monitor for faults with the main microprocessor 16. For this purpose, a connection 19 is provided. A resistor R1 is also provided to ensure that a fault in microprocessor 18 is unable to turn on driver 12 (ie R1 must be relatively high compared with R2 and the output resistance of the driver within
20 microprocessor 16).

Each time a microprocessor is powered up, the microprocessor is reset which usually involves most, if not all, of the pins of the microprocessor being re-set as inputs. The programming of the microprocessor then resets the pins to their
25 required state for proper operation. If the microprocessor incorrectly sets a pin to be an input rather than an output (or vice versa) clearly a fault with the microprocessor will exist.

In the arrangement of Figure 1 resistor R2 operates to ensure that if the output pin of the main microprocessor 16 that is connected to the high side driver 12 switches to become an input pin, then the high side driver 12 is switched to open and the effect of the load switched out. Resistor R2 is connected between the ground rail and the output pin of the main microprocessor that is connected to the high side driver 12. R3 is connected between the ground rail and the output pin of the monitor microprocessor 18 that is connected to the low side driver 14 and ensures that driver 14 is switched off while the driver output pin of microprocessor 18 is high impedance.

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The control system also includes a current sensor 20. This in itself may be a potential fault source since if it fails then the microprocessors are unable to detect this failure. This may be overcome by providing two current sensors in series. Alternatively, in a preferred embodiment of the invention, a back-up to the current sensor is provided by the monitor microprocessor 18 which calculates the current from the power supply voltage and the resistance of the load 10 by means of the equation $I = V/R$. This may also be achieved by monitoring the voltage at the high side driver 12 and the voltage at the low side driver 14, calculating the voltage drop across the load and, knowing the resistance of the load, calculating the load current.

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The results of the calculation may then be compared with the output of the current sensor 20 and if the difference between the two meets predetermined criteria (e.g. is less than or equal to a pre-determined threshold), then the monitor microprocessor 18 detects a fault with the current sensor and either switches out the load as a result (for a fail off system) or logs the fault for subsequent consideration. In the latter case, the control system would then rely on the current calculation to monitor the current which may not be desirable, depending upon the type of load and/or the field of application of the load.

25

The control system shown is applicable to many areas where the control of a drive is required. The invention has particular application to a gear control system, for instance as used in a vehicle, but this is not intended to be limiting.

5 In the field of vehicular gear control systems, the load 10 may be a gear box selector, a clutch selector, a valve in a pneumatics system etc.

In the foregoing specification, the invention has been described with reference to specific embodiments thereof. It will however be evident that various
10 modifications and changes may be made thereto without departing from the broader spirit and scope of the invention. The description and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

Claims

1. A control system for a load, the system comprising a first microprocessor having an output to drive one side of a load, a second
5 microprocessor having an output to drive the other side of the load, the system being arranged so that when either microprocessor detects a fault in the control of the load the load is switched off.
2. A system according to claim 1 wherein both microprocessors monitor
10 the current in the load.
3. A system according to claim 1 or 2 wherein a first resistor of relatively high value is connected between a driver output of the first microprocessor and an input of the second microprocessor, to allow the second microprocessor to
15 monitor if the first microprocessor is attempting to turn on the load.
4. A system according to claim 3 wherein a second resistor with a value less than that of the first resistor, is connected between the output of the first microprocessor and a low voltage to ensure a driver controlling the load is off
20 whenever the output of the first microprocessor is in a high resistance state.
5. A system according to any preceding claim wherein at least one of the microprocessors is arranged to calculate the current of the load by measuring the voltage across it and, when the load current does not meet pre-determined
25 criteria, to switch out the load.
6. A system according to any preceding claim wherein the control system
is a vehicular control system.

7. A system according to any preceding claim wherein the load is a gear box selector, a clutch selector or a valve.
8. A control method for a load, the method comprising a first
5 microprocessor having an output to drive one side of a load, a second microprocessor having an output to drive the other side of the load, the system being arranged so that when either microprocessor detects a fault in the control of the load the load is switched off.
- 10 9. A method according to claim 8 further comprising both microprocessors monitoring the current in the load.
10. A method according to claim 8 or 9 wherein the second microprocessor is arranged to monitor if the first microprocessor is attempting to turn the load
15 on by means of a first resistor of relatively high value between the driver output of the first microprocessor and an input of the second microprocessor.
11. A method according to claim 10 wherein the first microprocessor is monitored by means of a second resistor with a value less than that of the first
20 resistor, the second resistor being connected between the output of the first microprocessor and a low voltage to ensure the driver controlling the load is off whenever the output of the first microprocessor is in a high resistance state.
12. A method according to any of claims 8 to 11 further comprising at least
25 one of the microprocessors calculating the current of the load by measuring the voltage across it and, when the load current does not meet pre-determined criteria, switching out the load.
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13. A method according to any of claims 8 to 12 wherein the control method is applied to a vehicular control system.
14. A method according to any of claims 8 to 13 wherein the load is a gear
5 box selector, a clutch selector or a valve.
15. A control system for a load, the system comprising a first microprocessor having an output to provide a drive signal to drive the load, a second microprocessor to monitor the operation of the first microprocessor and
10 the operation of the load, the system being arranged so that when the second microprocessor detects a fault in the operation of the first microprocessor and/or the operation of the load, the second microprocessor is arranged to switch out the load or halt the operation of the first microprocessor.
- 15 16. A control method for a load, the method comprising driving a load by means of a drive signal provided by a first microprocessor, monitoring the operation of the first microprocessor and the operation of the load by means of a second microprocessor, when the second microprocessor detects a fault in the operation of the first microprocessor and/or the operation of the load, the
20 second microprocessor switches out the load and/or halts the operation of the first microprocessor.
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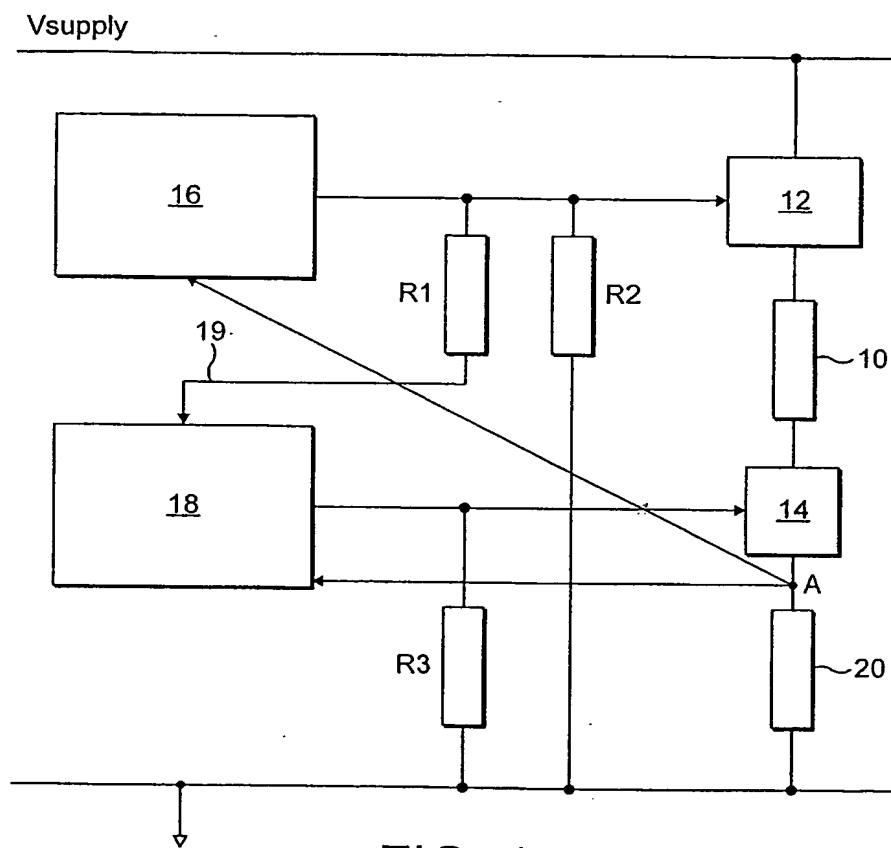


FIG. 1

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